(Lunar science for landed missions workshop)

Lunar Landing Site Candidates Discussed In the Japanese Science Community

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- Status of lunar landing missions in Japan
- SLIM project
- Science interests for lunar landing missions in Japanese communities

Status of lunar landing missions **(Lunar science for landed missions workshop)**

2005 2010 2015 2018 2020 2025 2030

SELENE lander was given up in 2000

SELENE (Kaguya): 2007 – 2009

SELENE-B、SELENE-2: canceled in 2015

SLIM (small landing demonstration mission) is on going to be launched in 2020

(Lunar science for landed missions workshop)

Beyond SELENE, Japanese lunar scientists are considering next lunarmissions:

In a decadal survey for Japan's lunar and planetary exploration (～2015)

Penetrator demonstration in the 1st half of 2020s

In-situ age determination in the 2nd half of 2020s

Sample return from farside highland after 2030

Recent research for cave exploration (2016～)

Lava tube in-situ at /sample return from lava tube and/or its skylight hole

On the other hand,
Research for top down lunar exploration (2014～)

In-situ measurement

Sample return

All have not been approved.

<Top-down (politics leading) projects>

Keywords:
- international
- pathfinding for human exploration

(under consideration)
- in 2020's first half, investigating water ice at polar region with India
- sample return from high-latitude with Europe and Canada, using Deep Space Gateway Station.

(both are in preparation for Mission Design Review (MDR))

(Lunar science for landed missions workshop)

SLIM project

SLIM project

SLIM (Smart Lander for Investigating the Moon)

SLIM started its plan in parallel to SELENE-2, by engineers of ISAS and universities in Japan.
In 2015, SLIM project was approved to be launched.

- to be launched in 2020
- Engineering demonstration
  Pin-point (< 100m) landing guided by automatic obstacle avoidance system.
- 100kg (incl. payload of less than several kg)
- Landing site and missions are in discussion

SLIM project

SLIM will reach the surface on the Moon by a new concept.

SLIM will intentionally tip over;

http://www.isas.jaxa.jp/home/kouga
28th_senryaku/06_nomi_senryaku28.pdf

Lunar Landing Site Candidates Discussed In the Japanese Science Community (examples)

(Lunar science for landed missions workshop)

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Key terms are
- Age
- Internal structures

Key terms Japanese lunar science community thinks important are

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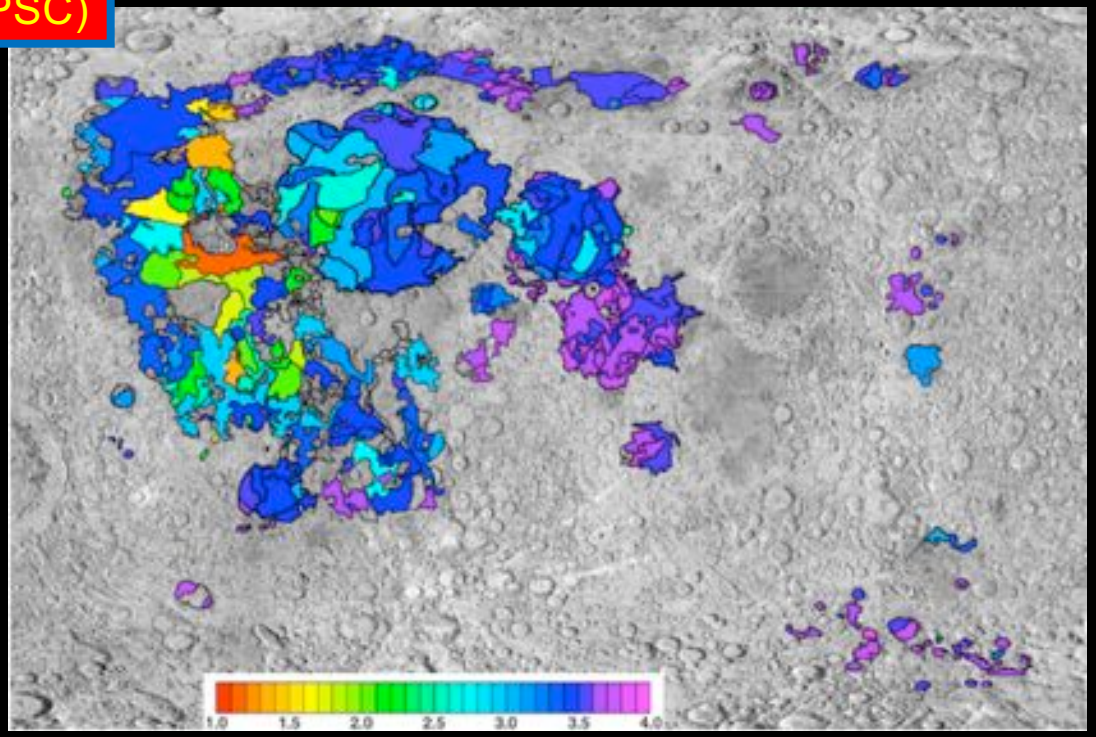
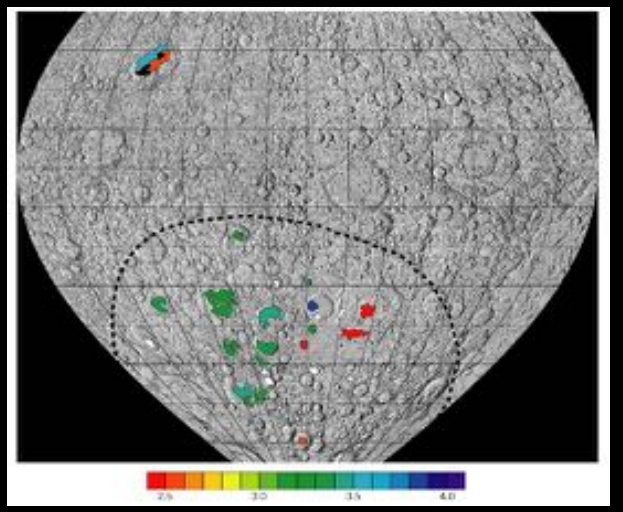
Model Age Investigation

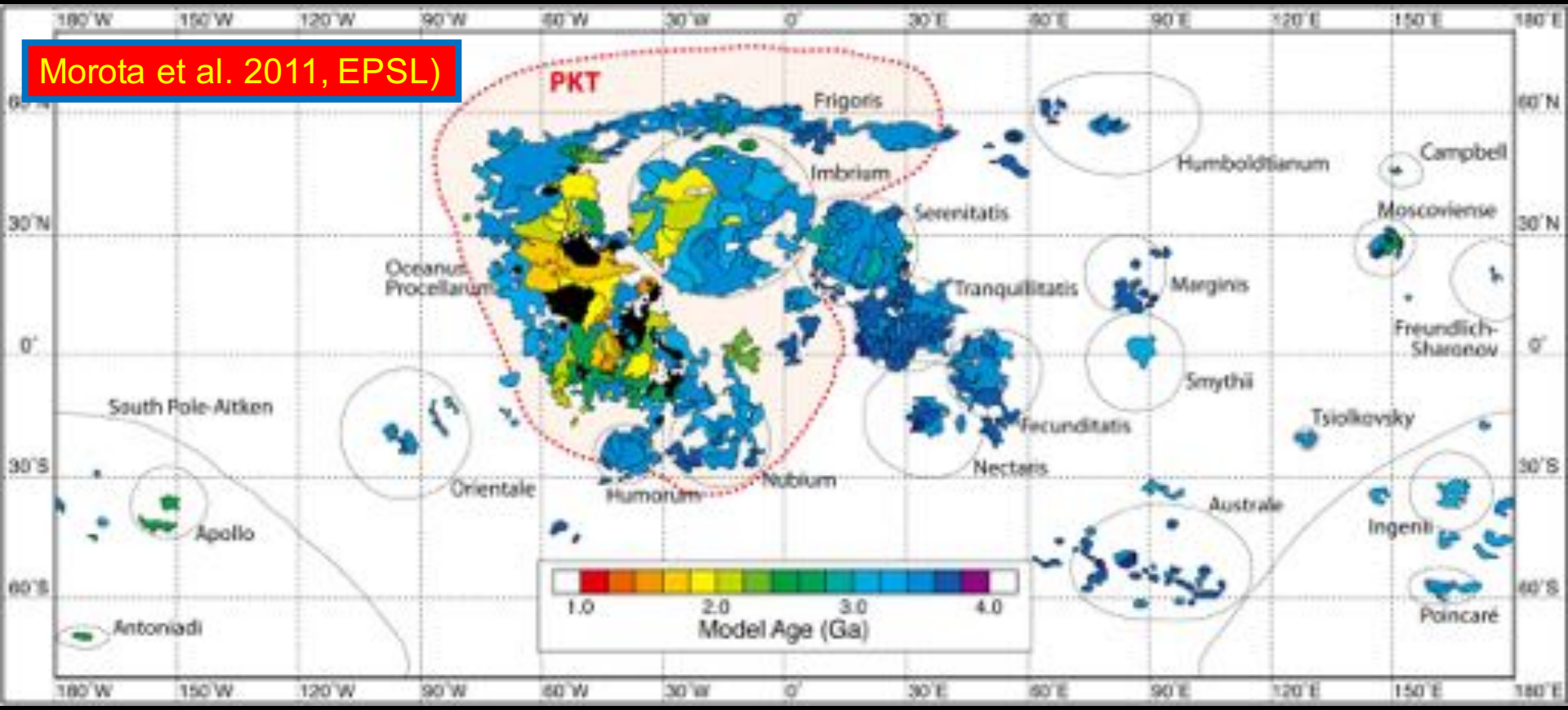
Hiesinger et al. 2008, LPSC)



Model Age Investigation

Based on SELENE TC data, model ages of
- Farside (Haruyama et al. Science, 2009)
- PKT region (Morota et al. EPSL, 2011)
- Others (Morota et al. EPS, 2013)
were investigated.



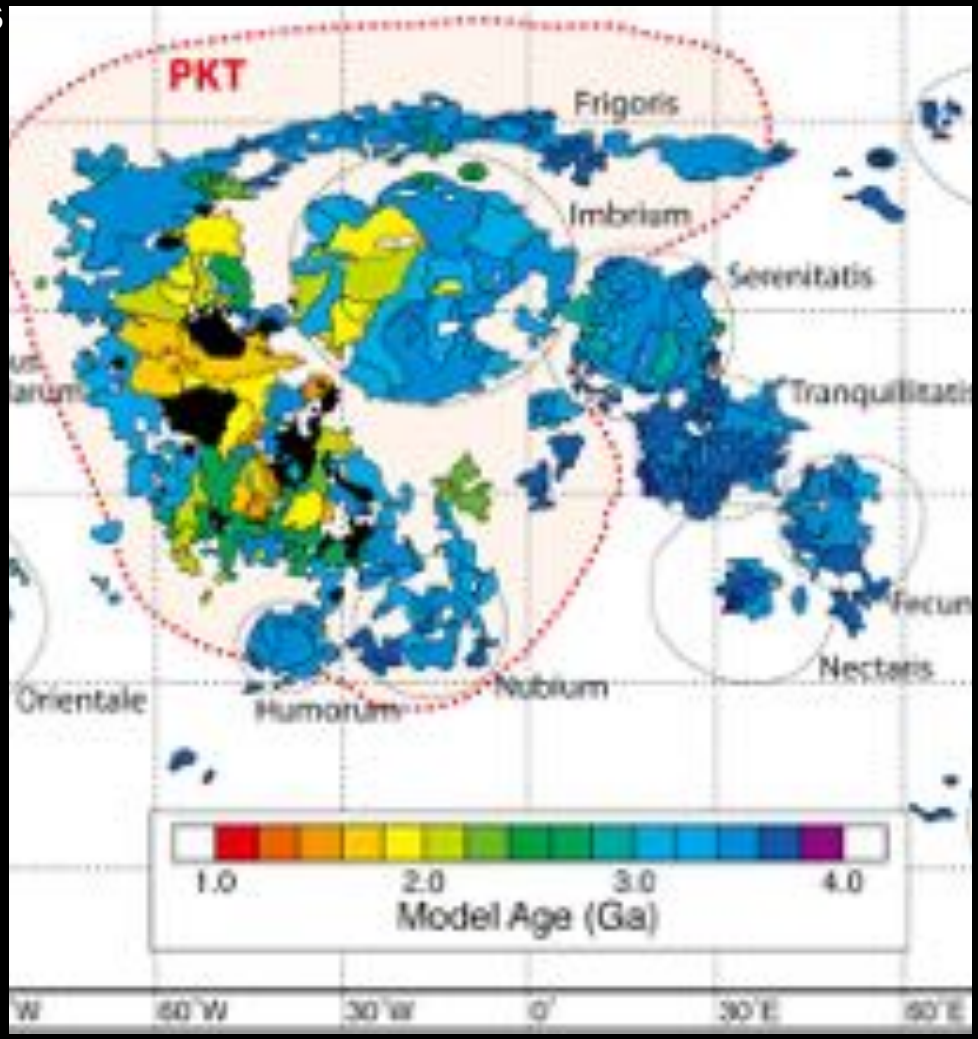


Model Age Investigation: purpose

～ 1 Ga for the youngest basalt units is based on crater chronology;

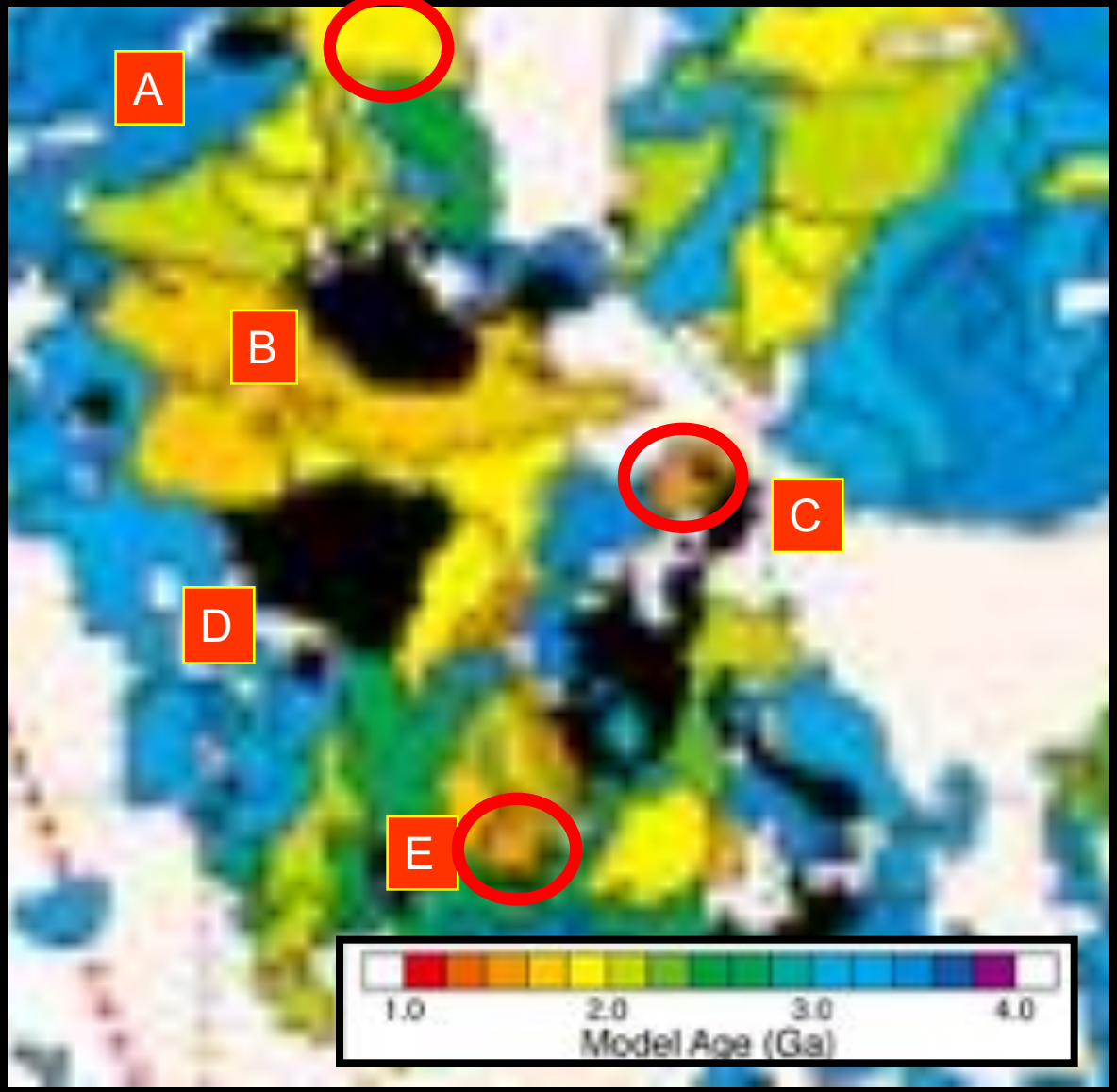
However,
～ 3 Ga for the youngest samples based on radiometric dating.
[e.g., Taylor et al. 1983; Nyquist et al., 2001]

Confirmation of consistency between model age based on crater chrologya and radiometric dating by in-situ at or sample return from geological units of young model age (2.0 -1.0 Ga) are required.



Morota et al. 2011, EPSL)

Model Age Investigation at PKT (center part of Oceanus Procellarum)



A. Mons Rümker

B. Arsitarchus Platau

C. Keplar Crater

D. Marius hills

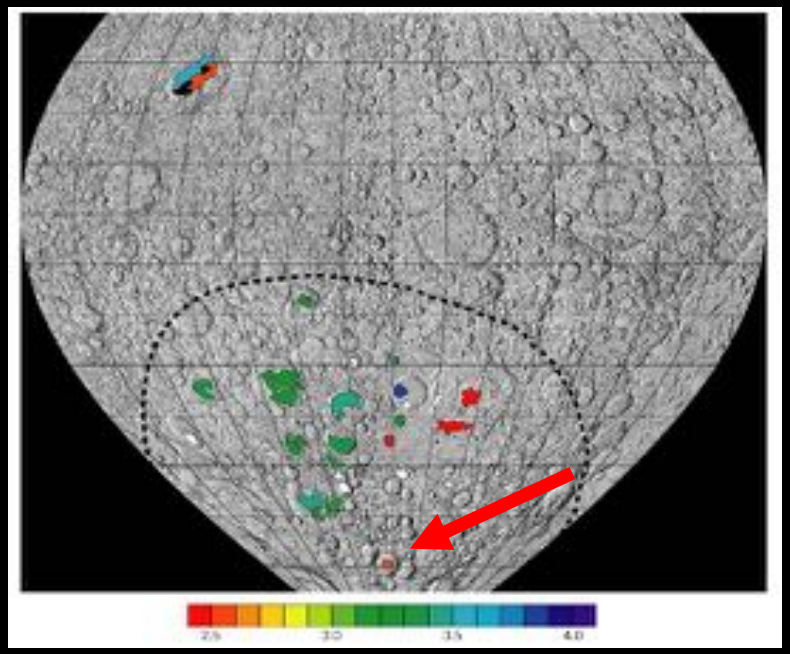
E. Flamsteed crater

Morota et al. EPSL, 2011

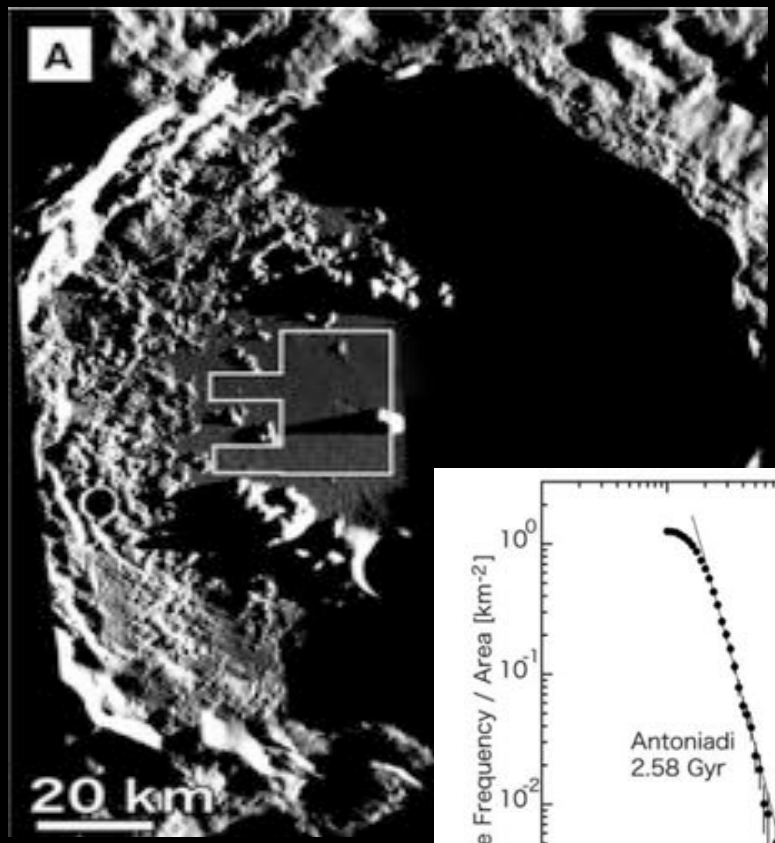
Age determination at high latitude

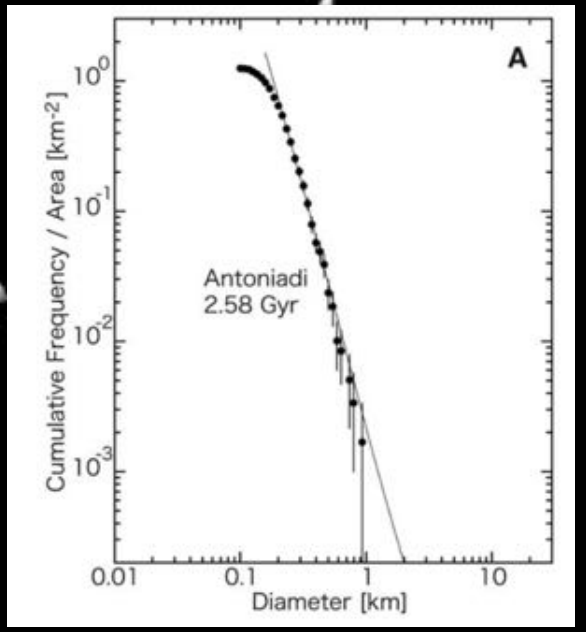
Model Age Investigation

High latitude Area



Antoniadi Crater
(69.7° S 172.0° W)

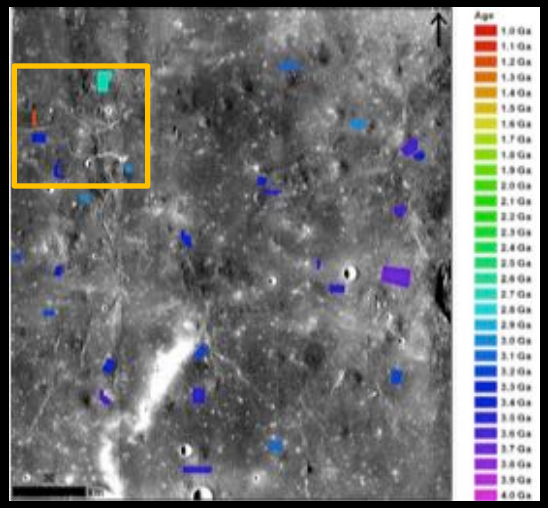


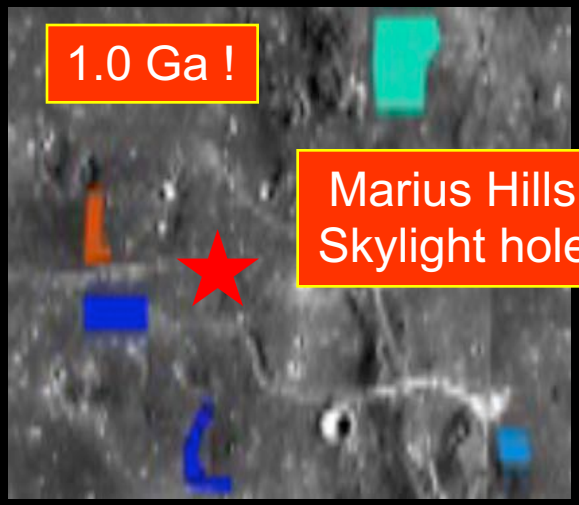


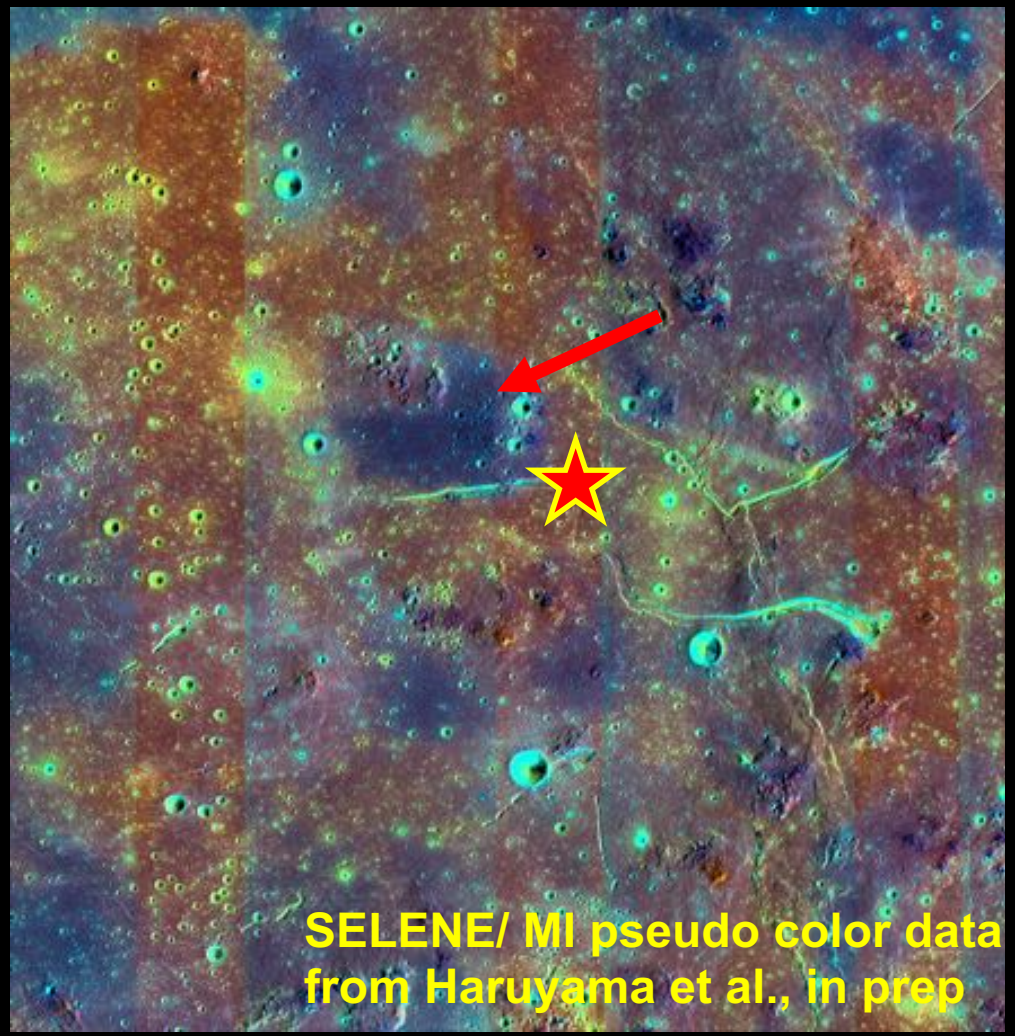
Haruyama et al., 2008, Science

Model Age Investigation near a skylight hole

Hiesinger et al. LPSC, 2016



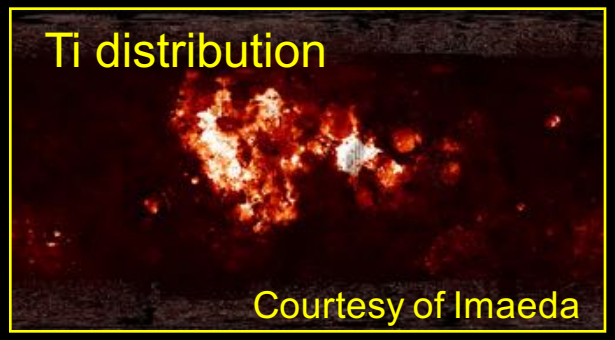


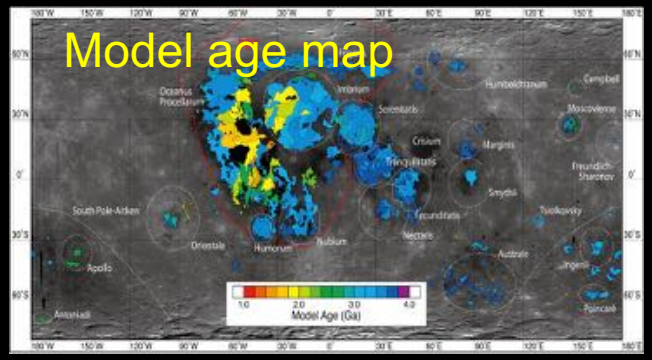


The accuracy of Crater Chronology is important to check a hypothesis.

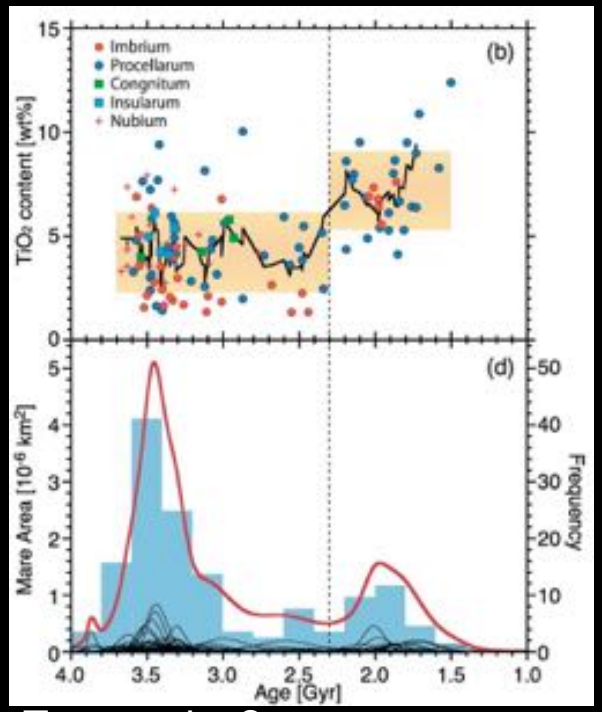
Hypothesis: hot plume at later stage

SELENE global data → A transition of Ti contents





Morota et al. (2016)



Two peaks ?
Hiesinger and Head (2003)
Kato et al.. (2015)

Kato et al. (2015)

To confirm this hypothesis,
we need younger basalt samples of < 2.0Ga old.

The accuracy of Crater Chronology is important to be checked.

Key terms Japanese lunar science community thinks important are

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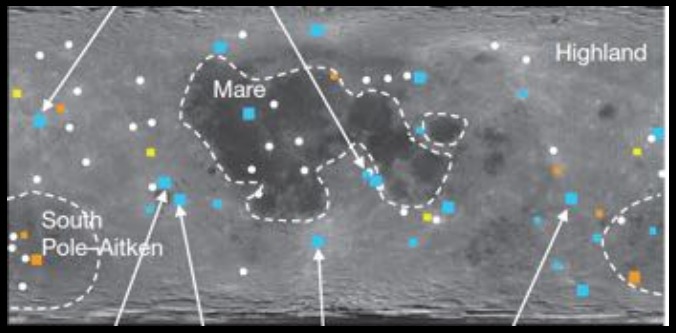
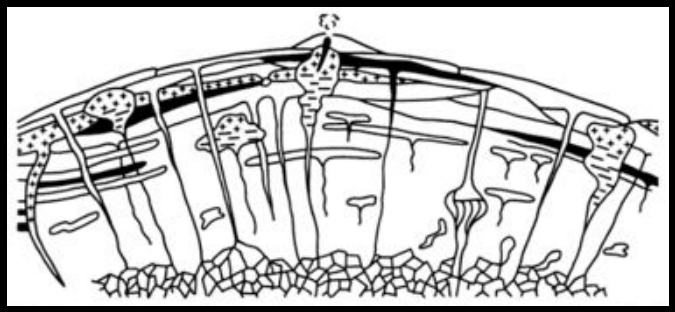
Hypothesis: massive PAN layer

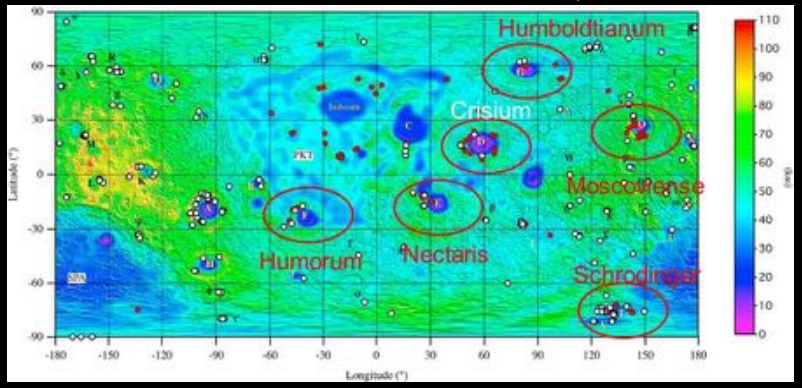
SELENE global data: ubiquitous PAN
Ohtake et al. 2010



Serial magmatism?



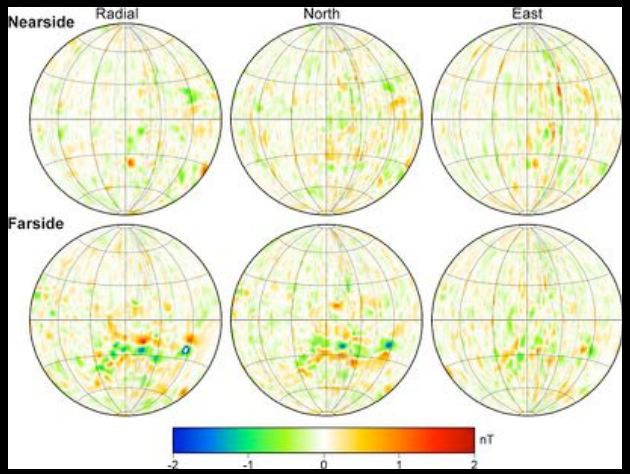
Yamamoto et al. 2010 ,2012: PAN and Olivine



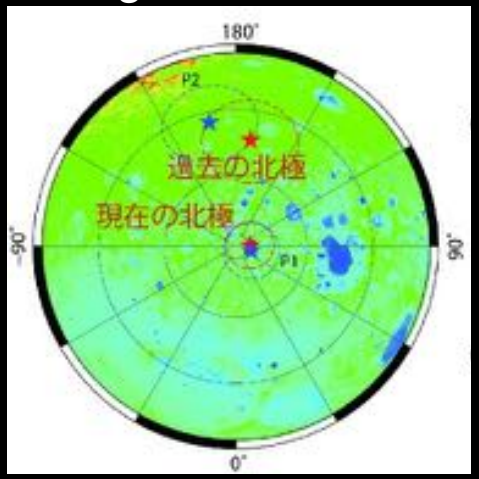
Mission in-situ at / SR from
PAN-Olivine coexistence area are required.

Hypothesis: Wander of magnetic axis

SELENE global magnetic field data → Wander of magnetic axis.

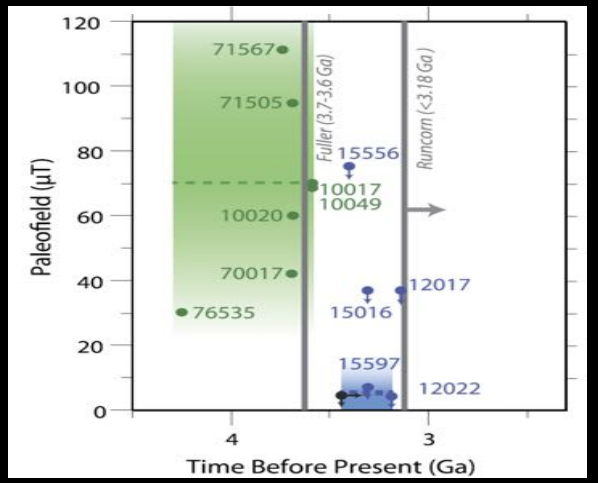


Tsunagawa et al. (2015)



Takahashi et al. (2014)

Sample data Zhang et al. (2013



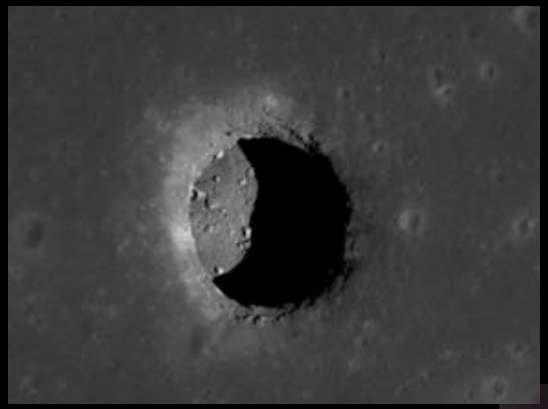
Peak of magnetic field was 3.8Ga.

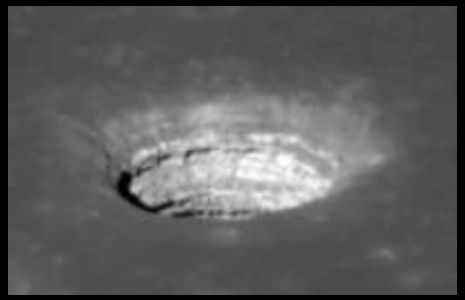
Investigation of Lunar dynamo is important to understand of lunar core formation and evolution.

Paleo magnetic field component data in various dates are required to understand core formation.

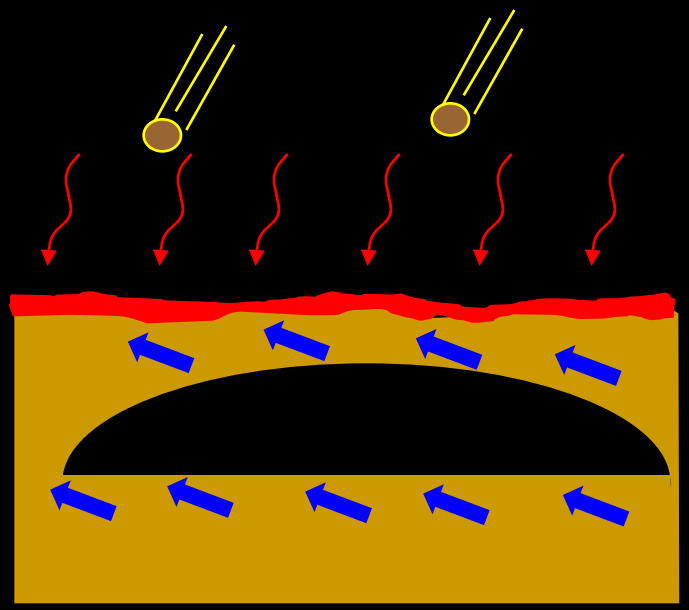
Hypothesis: Polar wander of magnetic axis

To investigate this hypothesis
lava tube and its entrance “skylight hole” is one of the best places .





LRO NAC images

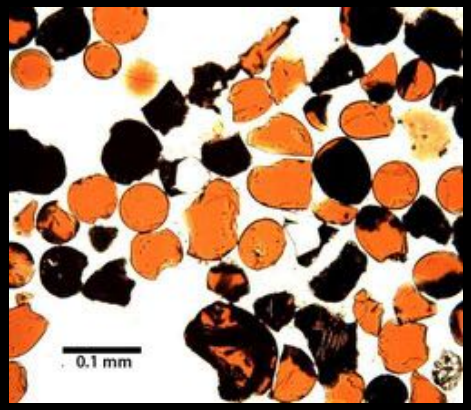


By knowing paleo dynamo magnetic field of the Moon, metal core formation of small celestial body like the Moon will be understood.

Hypothesis: Water “rich” interior

Samples with pores

Water Discovered in samples



Saal et al. 2008

Volatiles perhaps trapped In the wall of lava tube will tell us whether the lunar interior was rich or poor in water, and the origin of the water.

Summary

- Several Japanese lunar landing missions have been canceled.

- SLIM project is going.

- There are some riddles (hypotheses) from recent lunar exploration data.
- “Age” and “Internal structures” may be key-terms for lunar exploration in the next decade.

The Moon is fascinating.

Let’s return to the Moon, together.